On Line Stability Comprehensive Assessment and Preliminary Decision Technology Study

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Abstract

The application of online stability assessment and decision-making system is one important method to improve the power system stability. After many years study, China has developed the system and applied in many power system companies. The system play important role in actual operation, but some questions should be further studied to improve adaptability. Based on the system's current situation and actual requirement, the paper presents the main function and existed question of this system and put forward further studied functions, which include the steady state analysis, automatically identification of weak area and key fault, the future stability prediction, online stability composite quantification assessment and adaptability analysis of stability control strategy. The paper also presents the possible implementation approach.

Keywords

Online Stability Assessment; Supplementary Decision; Future Stability Prediction; Comprehensive Assessment

Introduction

The power grid of china has been developed to one large interconnect power grid including several regional, which brings great economic benefits. However, it also brings many potential problem and challenge. In recent years, china economy development rapidly, the load level increase and the power system construction accelerated. The power system operation mode change more rapidly because the rapid change of power system structure and power plant generation, especially the fast increase of new energy generation. The rapid change of operation mode requires promoting the power system analysis capability. With the formation of ultra high voltage and AC/DC power network, the inherent characteristics becomes more and more complicated, the power system control becomes more and more difficult. The control mode of this ULV power system should be changed. The power system fault may influence wider areas and become more serious. It is more difficult to prevent the fault influence. We must improve the emergency control stability. Compare with the offline power system analysis method, the online stability assessment system has more advantage to master the power system stability status and enhance the stability level, which has important role in power system operation.

Many countries have studied the online stability assessment method for many years. The main studies focus on steady state stability, voltage stability and dynamic stability. The main considerations include the line thermal stability, voltage stability margin, steady stability margin, transient stability margin and so on. The steady stability studies focus on if the system can be stable when small disturbance happen and the steady stability limit. The method mainly used is eigenvalue analysis method, another method is developed by DIMO. The DIMO method includes network transformation, generator simplification, REI equivalence and estimate the system stability status by DQ/DV, this method has been used in several online systems. The function of voltage stability assessment include computation of available transmission capability, voltage stability margin and voltage collapse point and the method used include continue power flow, minimum singular value, optimization method etc. The purpose of dynamic stability analysis is to find the fault may result in loss of stability and to compute the safe area. The time domain simulation can consider many detail models and is more accurate, but with the disadvantage of long computation time. It is better to use multiple machines in parallel system combined with the traditional time domain simulation software. Based on the time domain simulation, SIME method is developed. The SIME method predicts the system stability use the equivalence of generator angle dynamic curve data. Other methods are also used, which include energy function method, expert

experience method, matching online method etc.

China has studied the online stability assessment for many years and focus on online stability assessment and warning, online supplementary decision, online dynamic monitor. CEPRI is based on the time domain simulation software PSD and PSASP to develop the online stability analysis, transmission capability computation, supplementary decision etc. The data is from EMS state estimation. The online system used the analysis method and experience of offline simulation to improve the applicability. SGEPRI is based on the EEAC to develop system stability status monitor, evaluation and decision. It used the data from PMU and EMS and combined with stability control unit of actual system. The online stability assessment system is based on large scale parallel computation and visualization to develop the online static security analysis, online transient stability simulation, online short current computation, online small signal stability simulation, online voltage stability, EMS data transformation, fault screen, transmission capacity computation, supplementary decision etc.

The Characteristic of Current Online Stability Assessment System

After several years' study, the online stability assessment and supp-decision system has been developed and used in many electric power companies. The main functions include large scale parallel computing, EMS state estimation data conversion, online dynamic stability assessment, online transmission capacity computation, online supp-decision and so on. The online stability assessment system has become one important part of intelligent scheduling technology support system. Based on steady state data, dynamic data, the system realized steady state, transient state and dynamic state stability assessment. Figure 1 shows the main function of this system.
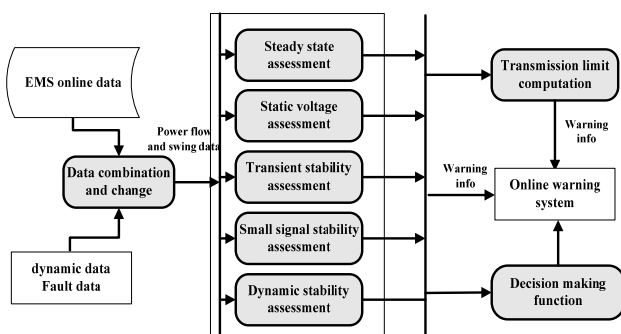

FIG1 THE CURRENT ONLINE STABILITY ASSESSMENT SYSTEM FUNCTIONAL STRUCTURE SCHEMATIC DIAGRAM

Data integration module integrates online EMS state estimation data, electric device parameter, power system model and fault data to form correct whole system power flow and swing data, then this data is changed to data of power system simulation software. Online stability assessment module realizes online computation of static stability, transient stability, small signal stability, static voltage stability etc. and gives warning when any stability problem exists. Online transmission capacity computation module computes the maximum transmission capacity and margin of specified transmission sections, this method adjusts the generator power and load to change the power of section and computes the steady stability and dynamic stability until loss of stability happened. The supp-decision module computes the adjustment control measures for steady stability, transient stability, small signal stability and voltage stability, which including generator power, parallel capacitor, HVDC power, load and so on.

The current online stability assessment system has been used in many power system companies and has played an important role. However, the system still exist some questions and some functions should be improved such as the operation efficiency, online data quality, practical level and so on, which need to study new method. The main questions are as following:

1) The online computations are only based on specific fault, transmission sections which are come from experience persons. The system status may change rapidly in online operation especially when bad weather happened. The specific data may not adapt to the system status change.

2) The main function is only the computation of power flow, transient stability, short current, small signal stability etc. Display of large amount of data cannot intuitive reflect the system status and need the comprehensive analysis result based on the computation result.

3) The supp-decision function is not practical. Many different methods have been used. However, the theories of these methods still need further study. The inherent characteristic of power system should be considered. The control methods should consider generator, load, HVDC comprehensively.

4) The computation cycle is about 10 minutes. When the computation is finished, the power system status may change rapidly, especially in the morning and night. It may be necessary to predict the future status, such as 30 minutes later.

5) Large amount of experience has been accumulated in the day-to-day power system computation and studies, which should be used in the online system.

Therefore, it is necessary to study further combined with the power system theory and power system operation experience, to promote the development of online stability assessment system.

The Main Function Needed to Study

With the development of ultrahigh voltage ac and dc power system network, the operation modes become more and more complex and the influent area of power system fault is extended to regional power grid. The online stability assessment system needs to be more adaptive to the current system.

The online stability assessment system mainly includes two function modules which is online stability assessment and online supp-decision. The online stability assessment function module is the basic and hard core, which is basis of the online supp-decision function module. Figure 2 is the new system functional diagram.
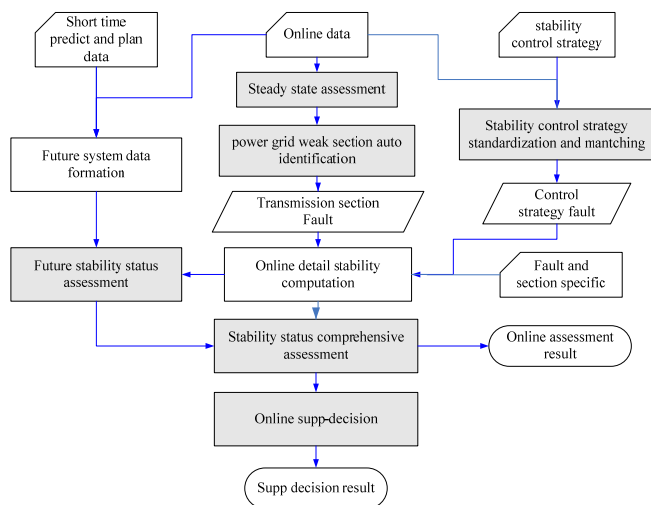

FIG 2 NEW SYSTEM FUNCTIONAL DIAGRAM

The online stability assessment system functions include power grid weak section auto identification, power system stability status comprehensive assessment, the system stability status prediction, online validity analysis of offline stability control strategy. In order to realize the online stability assessment functions, the first step is to study the power grid weak section auto identification method to identify the power system weak sections and key fault; the second step is to study the management of stability control strategy and automatic matching with the online data to find the current control strategy, all the

result of the two steps become the basic data of online stability assessment function for detailed online computation; the third step is to combine the current online data with short period prediction and planning data to form the future data, which is used to assess the stability changing trend; the last step is to comprehensive assess the system stability status based on the result of power grid weak section auto identification, the system stability status prediction and online validity analysis of offline stability control strategy. The whole online stability assessment function is basis of supp-decision system. The new function detailed in the following:

1) *Power System Steady State Assessment*

From the perspective of steady state, it is necessary to study the power system power flow distribution, steady N-1, voltage level, active and reactive power reservation and balance and so on. The result also needs to compare with history result to find the power flow change procedure. The purpose of this function is to further master the steady status of power system.

2) *Power Grid Weak Section Auto Identification*

When the online data is available, it is first to auto find the important transmission section and fault. The actual operation mode is complex and the specific transmission and fault may be invalid. The result of this function is the important part of the basic data. In this function, it must be find the weak area in short time and the system stability level also must be evaluated approximately.

3) *The Future Stability Status Prediction*

The current online data, short time prediction and planning data are usually available. Based on these data, we can form the future power flow data, such as 30 minutes, which is basis of future status assessment. It is necessary to assess the future stability quickly because the online time is short. This function includes the data formation and stability fast assessment based on the main characteristic and current detail computation result. When the future stability estimation is finished, it is possible to find the problem of future and take measure ahead of time.

4) *Stability Control Strategy Online Assessment*

The offline stability control strategy is very important for power system operation. If the

system operation mode is changed, it may be invalid. This function uniforms the offline strategy, finds the suitable control strategy of the current online data and computes the transient stability to assess the validity. This function also can compute the new suitable control measure.

5) Power System Stability Comprehensive Assessment

The key transmission sections and key fault have been found, the offline stability control strategy has been verified, the current online stability has been detail computed and the future stability has been predicted, the stability level of whole system should be valued comprehensively. It is necessary to change the form of large amount of data list and to give the system level directly.

6) Online Supp-decision

If some questions existed after detailed online stability computations, the system must find the countermeasure to assist the operator to adjust the generator, load or other advices to overcome the problem. The online supp-decision function must overcome different type problems, such as steady static problem, transient problem etc. The procedure includes identifying stability type, finding adjustable area and devices, verifying the validity of measure and giving the result. The adjustable device may include generator, load, HVDC and so on.

Discussion of Realized Method

Power System Steady State Assessment

From the steady state assessment point, it is always interesting in the power flow distribution, voltage level, active power reservation, reactive power reservation, steady state N-1 overload and so on. The first part of online stability assessment should be the steady state assessment, which purpose is to assess the reasonable degree of the operation. The methods used in the steady state usually are mature. However, it must be combined with the characteristic of actual power grid and day-to-day analysis experience to analyze more and give all the necessary information.

The functions needed to be considered in the steady state assessment include:

1) Active power distribution, including sending area and load area identification, active power distribution of the transmission line, overload, active power reservation, power loss etc.

2) Reactive power distribution, including if the reactive power is distributed with hierarchical partition principle, the reactive power reservation, the rationality of generator reactive and load reactive, the distribution of generator reactive power and shunt reactive compensation etc.

3) voltage level, including if the voltage is in limit, the voltage level of different areas, if there exist some lines or transformers which voltage difference is larger etc.

4) steady state N-1 analysis. If there are some overload lines and transformers in steady state N-1 condition, if the voltage change of bus is large.

5) steady state limit. For some weak transmission line, the steady state limit of normal status should be computed. At the same time, the steady state limit change considered some branches disconnect is specially pay attention.

Power Grid Weak Section Auto Identification

The current online stability assessment is based on the specific data, that is the transmission section and fault is specific by person, using the traditional transient stability, short current, small signal stability program. Because of the uncertainty of power system operation, the data specified by person may be invalid, some more dangerous fault or some weaker transmission sections may be lost. Therefore, it is necessary to identify the weak transmission sections and key fault automatically. Because of the timeliness of online application, the function must be finished in short time.

This function need to study the power grid stability evaluation method to approximately master the stability of whole network in short time without large amount of computation. The result should include the important transmission sections, weak areas, key fault and these data is also the basic data of next detail computation. The main research questions include:

1) the transmission section automatically research. It must identify all sections including the different voltage level section. There are many different methods can be used. It can use the characteristic of hierarchical partition, the power flow transfer when some lines disconnect, topology analysis method etc.

2) the important transmission sections determination method. After all transmission sections have been

found, we must determine which one is important. It must be determined from several aspects, such as steady N-1 overload, transmission limit, voltage stability level, damping etc. It is very important to consider the change when some lines or transformers disconnect.

3) the important fault determination method. There are many factors affect the fault severity, such as the shock degree of short, the influence of some lines disconnect, the physical structure and inherent characteristic of power grid etc. After the important transmission sections is find, it should find the key fault considering the distribution of weak transmission sections, short current, redistribution of power flow, the stability characteristic of power grid.

The Future Stability Status Prediction

The current online stability assessment is only based on the current online data every 15 minutes. Large computation is executed in this period. When the computation is finished, the operation mode is changed. During some special time, the change may be great and the assessment result is not applicable. At the same time, there exist many short time prediction and planning data, such as 30 minute. It is possible to use this data to form new data to fast assess the future system stability ahead of time.

This function is based on the short time prediction and planning data, such as load forecasting data, generator planning and transmission section planning of 30 minutes, to fast predict the future stability status. The main studied questions are as following:

1) the future data formation and adjustment. The basic data include the current online data, prediction data and planning data. This function must combine all type data and adjust to form feasible power flow data. The key technology are different type of data combination and power flow data automatically adjustment. the data quality also is one important factor.

2) the future stability status fast prediction. After the data has been formed, the traditional computation method can be used to assess the stability. However, because of large amount of computation, it needs long time. Because of the timeliness of online application, it is difficult to use the traditional method; the fast assessment method should be studied. It is possible to use new method to fast assess the new stability status based on the current computation result. The new method can select some important data to estimate the

change degree and direction, such as overload level, transmission limit change and damp change.

Stability Control Strategy Online Assessment

The stability control system is very important in the power system operation and the control strategy is computed with offline large amount of operation data. The power system become more and more large and the characteristic become more and more complex. It is possible to exist some operation mode in which the stability control strategy is invalid. So it is necessary to check the control strategy validity based on the online data.

The main idea is: based on the online data used in the online stability assessment system, for the current offline stability control strategy, realize the standardization, online matching, checking and optimization. The main steps are as following:

1) standardization of control strategy. The format of the offline stability control strategy is very complex, which is easy understood for people but is difficult for computer. So it must be change the format to suitable for compute input first. This function include setting standard, editing interface design and develop, control strategy analysis program development.

2) online matching and checking. The stability control strategy is suitable for different operation mode. For one online data, it should be match the control strategy and the power flow data to find the valid control strategy. It need to analyze the power flow data detail to find the information relate to the valid conditions of control strategy, such as the power grid structure, operation data, judgment logic etc. Then the valid control strategy is change to fault data and is computed by the simulation software.

3) new control strategy computation. New stability control strategy can be computed based on the online data to be more suitable to actual power system. One of method is based on the offline control strategy to optimization. The other method is to directly compute the new control strategy, the important problem include which question is it, how to find and order related device etc.

Stability Comprehensive Assessment

The purpose of large amount of computation is to understand the whole system stability level. How to display the system stability status is very important. If all the computation result is list in the screen, the main information cannot be clearly found. So it is necessary

to display the stability level in more direct way, which must be analyzed and summarized from the large amount of data. The whole system stability level must consider the current detail computation result, weak area distribution, future stability trend, stability level of history and so on. The result display can use the form of quantitative, such as first class, second class, third class and fourth class or red, orange, yellow and green.

Conclusion

This paper is focus on the online stability assessment technology development, includes the current situation and further studied question. The current online system includes two function modules which are online stability assessment and online supp-decision. It is mainly use the traditional simulation software to compute. In order to better meet the actual demand, some new functions should be further studied. The online stability assessment is the basis of whole system and the new function should include power system steady state assessment, power grid weak transmission sections and key fault fast identification, The future stability status prediction, stability control strategy online assessment and stability comprehensive assessment.

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